Section 6.0

MCWL/DARPA EFFORTS

The dynamic nature and trajectory of new technologies have the potential to provide dramatic improvements to the systems within the PEO LS portfolio, as well as providing increased capability to the warfighter. Therefore, PEO LS strives to enhance its body of technical knowledge by monitoring relevant efforts of cutting edge organizations such as the Marine Corps Warfighting Lab (MCWL) and Defense Advanced Research Projects Agency (DARPA). These efforts expose the S&T Director to advanced concepts and emerging technologies with the potential to address current and/or possible future capability gaps.

This section presents many of the technologies that the PEO LS S&T exploration process has identified as possessing potential to address current/future capability gaps. While these programs represent only a fraction of MCWL and DARPA's overall portfolios, which encompasses a much broader spectrum of military technology development, the identified programs appear to have the greatest applicability to the PEO LS effort.

Marine Corps Warfighting Lab (MCWL)

The mission of the Marine Corps Warfighting Laboratory is to conduct concept-based experimentation for the identification, development, and integration of operational concepts with tactics, techniques, procedures, and technologies to improve the naval expeditionary warfighting capabilities across the spectrum of conflict for current and future operating forces.

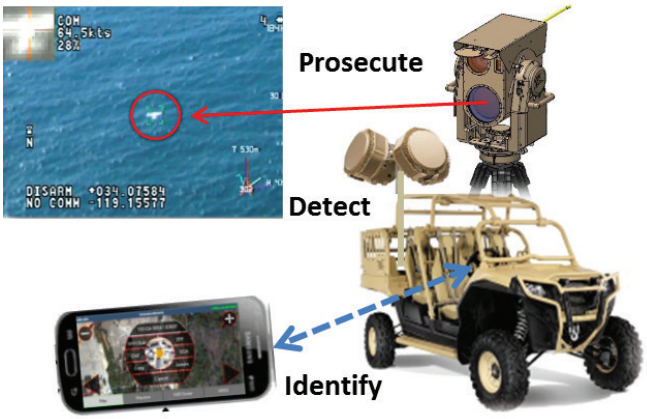
The Science & Technology (S&T) Division supports the MCWL Commanding General in carrying out his responsibilities under Deputy Commandant for Combat Development & Integration (CD&I) as the Executive Agent for Marine Corps S&T and experimentation to develop advanced warfighting concepts and capabilities. The S&T Division works in conjunction with Office of Naval Research (ONR), Defense Advanced Research Projects Agency (DARPA), Department of Defense (DOD), Marine Corps Systems Command (MCSC), Program Executive Office, Headquarters Marine Corps (HQMC) and industry partners to develop the vision, policies, and strategies needed to exploit scientific research and technological development in support of USMC combat development and experimentation.

The following MCWL programs have been identified as most relevant to the PEO LS portfolio and demonstrate the potential to support the future direction of the PEO.

Counter Unmanned Systems (CUxS)

CUxS is an integrated, expeditionary suite of networked capabilities to detect, identify, and track, cue and kinetically or non-kinetically prosecute enemy unmanned air, ground, and surface/sub-surface systems. The objective is to demonstrate the ability to execute an end-to-end C-UAS killchain in a distributed operational environment. With the technical approach to demonstrate a collaborative effort between MCWL, CDD/FPID, AMRDEC (U.S. Army), VMX-1, and ONR to leverage

resources and subject matter expertise while experimenting with technologies which support the overall objective of this project. In addition, the performers include CDD/FPID (AoA, U-UNS), AMRDEC (tech, integration), VMX-1 (integration, testing), ONR (tech), DRS (radar), and Aleta Technologies (tech). For CUxS, the S&T thrust area is Force Protection. Some significant EF-21 linkage quotes include "...fully interoperable and scalable to the particular mission. Platforms will be networked to allow for dispersed operations." (pg. 35) as well as "defending the MAGTF from ground, air (includes counter UAS), missile, and cyber-attack." (pg. 37). The major stakeholders involved with this program include CDD/FPID, PEO LS, VMX-1, MAWTS-1, MEFs, and SPMAGTF.



TACAD Supply Glider

The TACAD Supply Glider is a disposable cargo glider for standoff precision aerial resupply. The glider folds for transport and its wings unfold after deployment. It can be dropped either from a sling or deployed via static line from internal transport. The objective is to demonstrate capability to deliver cargo to multiple resupply points from one rotary wing (manned or unmanned) mission, while minimizing parent aircraft flight time. The technical approach will have two competing vendors designing and developing prototype capabilities to prove that a disposable system will be militarily suitable. The performers include InSitech, Logistic Glider Inc., and Yates Electrospace Inc. For TACAD Supply Glider the thrust areas consist of Expeditionary Logistics, Autonomy/Robotics, and Maneuver. Some significant EF-21 linkage quotes include, "a major corollary to sea-basing is the reduction of the logistics footprint ashore. The former footprint must be reduced and will move to the sea-base. As well as "the new footprint will be characterized largely as a transportation/distribution system that delivers sea-based supplies to smaller and significantly dispersed units." The major stakeholders involved with this program include LID, I&L, MAGTF Sea-basing and CSS elements.

Robotic Vehicle Modular (RV(M))

The Robotic Vehicle (Modular) is a multi-purpose Unmanned Ground Vehicle (UGV), hosting modular payload architecture and providing the ability to rapidly change out payloads for a variety of missions. The objective is to provide an Expeditionary Landing Team (ELT) with a highly mobile, MV-22 transportable, multiple payload, tactical-scale, platoon-level, infantry support Unmanned Ground Vehicle (UGV) to be utilized in a multitude of missions. In addition, the performers include MCWL, ONR 30 Fires, NSWCDD, TORC, ARDEC, and Pratt Miller. For RV(M) the thrust areas consist of MAGTF Fires, C4ISR, Autonomy/Robotics, Maneuver, Logistics, and Force Protection. The Marine Corps operating concept linkages begins with the ability to refine the concept of manned-unmanned teaming (MUM-T) to integrate robotic autonomous systems (RAS) with manned platforms and Marines. Develop CONOPs that support and embrace RAS as a critical enabler. As well as the ability to exploit man-machine interface and manned-unmanned teaming to overcome challenges in urban terrain. Develop fires solutions that enable precise effects in compartmentalized terrain. While also having a way to incorporate as quickly as possible unmanned ground vehicles across the MAGTF to enhance survivability, increase lethality, and reduce manpower requirements. Along with the capability to explore MUM-T technologies for

logistics applications. The focus area for CG and MCWL/FD are the autonomous, robotic and unmanned technologies with emphasis on manned/unmanned-teaming. The major stakeholders involved with this program include MCWL, MCCDC, FMID, JGRIT, DME, JCRAS, ONR 30; DTRA, ARDEC, TARDEC, NSWCDD, TORC, and PME.

Unmanned Tactical Autonomous Collaboration and Control (UTACC)

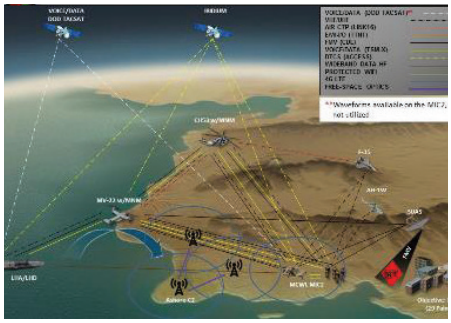
UTACC is a decentralized multi-UxS manager, enabling UxSs to act collaboratively within and across domains and team with manned operations. UTACC will significantly minimize operator intervention over current systems and allow the system the flexibility required to react to a wide range of operational tasks, environmental conditions, and landscapes as based on the real-time needs of the operator. The objectives are to demonstrate the software-level infrastructure on multiple UxSs in a range of environments and conduct multi-UxS mission incorporating intuitive control and robust localization. In addition, the performers include SNC, NPS, IHMC, NSWCDD, Endeavor Robotics, and Boston Dynamics. The major stakeholders involved with this program include MCWL, CD&I, JGRIT, DARPA, ONR, and NPS. The focus areas for CG and MCWL/FD are MAGTF Command & Control with emphasis on minimizing and maximizing digital interoperability in disaggregated, communications-degraded environments. As well as autonomous, robotic and unmanned technologies with emphasis on manned/unmanned-teaming. The Marine Corps operating concept linkages begins with the ability to refine the concept of manned-unmanned teaming (MUM-T) to integrate robotic autonomous systems (RAS) with manned platforms and Marines. Develop CONOPs that support and embrace RAS as a critical enabler. As well as the ability to exploit man-machine interface and manned-unmanned teaming to overcome challenges in urban terrain. While also having a way to incorporate as quickly as possible unmanned ground vehicles across the MAGTF to enhance survivability, increase lethality, and reduce manpower requirements. Along with the capability to exploit man-machine and artificial intelligence interface to enhance performance.

Unmanned Logistics System-Air (ULS-A) (BLI 10380)

IF the GCE/LCE is equipped with an organic unmanned aerial delivery platform capable of carrying 50-600 lbs…THEN ground resupply missions and the attendant draw on combat power and effectiveness can be reduced. This project will deliver prototypes capable of automated aerial resupply utilizing emerging commercial single or multi-rotor airframe technologies. Some operational goals of this project is that it will help reduce risk to personnel conducting manned resupply operations in contested terrain, it will provide organic aerial resupply capability at the company level, which increases unit flexibility for conducting sustainment operations, as well as provide assured resupply for steady state and emergency operations that unburdens dismounted units over extended distances. The main CG, MCWL Focus Areas are 3 and 6. Some significant MOC linkage quotes discuss modern force which exploits innovative concepts and approaches. These quotes include "…reduction of the logistics footprint ashore…" as well as "Increased capacity to employ unmanned aerial system (UAS) from naval platforms and connectors supporting timely target acquisition". The major stakeholders involved with this program include MCWL, ARDEC, CENTCOM, I&L, and CD&I.

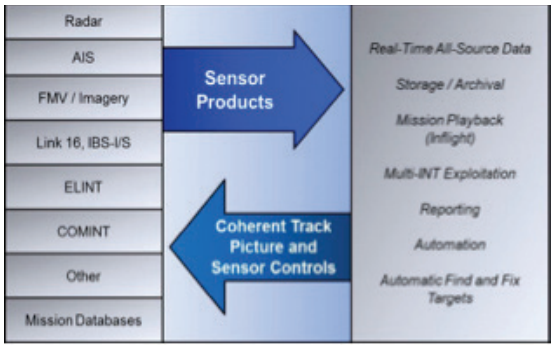
MAGTF Integrated C2

MAGTF IC2 will be a closed black core, service-oriented, IP-based network with open architecture that communicates via numerous C4 and intelligence wave forms, processes the data sent & received, and then shares the resulting actionable information with dismounted Marines and C4I platforms. The system will support multiple applications to allow effective awareness and communication across every warfighting function--over the horizon, on the move and within amphibious ships. The system will function in a variety of operational environments, to include the mega-city, the jungle, the open desert and mountainous terrain with potential be transported by both manned and unmanned systems. There are six major goals of the MAGTF Integrated C2. The first goal is to participate in various scheduled activities. Goal number two is to begin developing company level "5th Generation" like data fusion capability utilizing Minotaur to increase shared awareness and enable Information Warfare & disaggregated operations. The third goal is to merge IC2 & NOTM ITV capabilities into a single platform (threshold) w/ a vehicle agnostic form factor (objective). Goal number four is to have RF signature reduction utilizing Low Probability of Detection and/ or Low Probability of Intercept technologies to mitigate "unmanaged signatures" (e.g. Free-Space Optics, Cognitive Radios, Spread-Spectrum Waveform, 4G LTE). The fifth goal is to investigate, and if feasible, engineer ACCESS (DTCS Phase 3) security enhancements to meet NSA requirements under the Commercial Solutions for Classified (CSfC) Security Program as well as integrate other operationally relevant features that would enable future operational transition. The final goal is to investigate alternatives to ANW2 for tactical level local distribution of data. With the technical approach to have incremental improvements through spiral development and integrate new capabilities based upon lessons learned through test and experimentation. In addition, the performers include MCWL, NSWCDD, NRL, JHAPL, Oceus, TrellisWare, and Iridium. Some MOC linkage quotes include "Naval forces will require the ability to collect, process, and disseminate relevant information in near real-time to support distributed fire and maneuver at the operational and tactical levels. "(p. 34-35), "...fully interoperable and scalable to the particular mission. Platforms will be networked to allow for dispersed operations." (p. 35), and "battlefield sensors and activities should be linked by a sensing strategy that combines all sensor data...that transforms into battlespace awareness." (p. 38). Other POM18 MCGL linkage include GAP #: 12, 27, 44, 49-56, 61, 64, 73, 80-84, 86, 97, 101, 127, 132-133, 147, 154, 177, 193, 209, 213, and 221. As well as some 2017 UPL linkage which include 40743-Special Purpose Marine Air Ground Task Force (SPMAGTF) En Route C4, 40781-Broadband Meshable Data Link (BMDL), 40805-Marine Corps Intelligence, Surveillance, Reconnaissance Enterprise (MCISRE), and 40808-MAGTF Secondary Imagery Dissemination System (MSIDS) Short Wave IR Full Spectrum. The major stakeholders involved with this program include NSWCDD, NAVAIR, PM MC3 NOTM, DC/A, DC/I, and JT Staff J6.



Minotaur

The goals of Minotaur at the Company level, provide multi-sensor ISR fusion capability that performs true data fusion resulting in improved accuracy for Geo-Registration of targets, automated target detection and automatic classification significantly better than that of any capability the sensors may have organically and statistically better than what a human can perform. Additionally, provide the ability to not only select and view Full Motion Video (FMV) feeds, but to allow operators the



opportunity to directly manipulate the sensor in real time using very simple inputs. Be able to derive operationally enhanced situational awareness to leadership and then send actionable information to handheld devices, with Fires/Situational Awareness Software such as KILSWITCH, over links as small as 2.4Kbps (Iridium). With the technical approach to integrate the Minotaur software so that it operates within MIC2 and functions with MIC2's available means of C2 input and output. In addition, the performers include JHAPL, NAWC China Lake, and NSWC Dahlgren. Some MOC linkage quotes include "Naval forces will require the ability to collect, process, and disseminate relevant information in near real-time to support distributed fire and maneuver at the operational and tactical levels." (p. 34-35), "…fully interoperable and scalable to the particular mission. Platforms will be networked to allow for dispersed operations," (p. 35), and "battlefield sensors and activities should be linked by a sensing strategy that combines all sensor data…that transforms into battlespace awareness." (p. 38). Other POM18 MCGL linkage include GAP #: 12, 27, 44, 49-56, 61, 64, 73, 80-84, 86, 97, 101, 127, 132-133, 147, 154, 177, 193, 209, 213, and 221. As well as some 2017 UPL linkage which include 40743-Special Purpose Marine Air Ground Task Force (SPMAGTF) En Route C4, 40781-Broadband Meshable Data Link (BMDL), 40805-Marine Corps Intelligence, Surveillance, Reconnaissance Enterprise (MCISRE), and 40808-MAGTF Secondary Imagery Dissemination System (MSIDS) Short Wave IR Full Spectrum. The major stakeholders involved with this program include NSWCDD, NAVAIR, PM MC3 NOTM, DC/A, DC/I, and JT Staff J6.

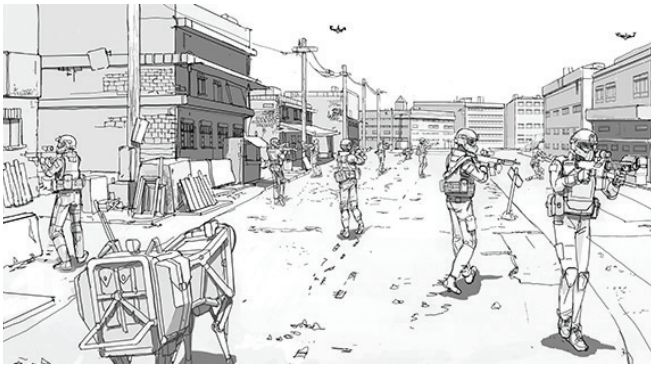
Defense Advanced Research Projects Agency (DARPA)

Established in 1958 as part of the U.S. Department of Defense, DARPA is designed to pursue opportunities for transformational change rather than incremental advances. Its mission is to make the pivotal early technology investments that create or prevent strategic surprise for U.S. National Security. DARPA explicitly reaches for transformational change instead of incremental advances. But it does not perform its engineering alchemy in isolation. It works within an innovation ecosystem that includes academic, corporate and governmental partners, with a constant focus on the Nation's military Services, which work with DARPA to create new strategic opportunities and novel tactical options. For decades, this vibrant, interlocking ecosystem of diverse collaborators has proven to be a nurturing environment for the intense creativity that DARPA is designed to cultivate.

The following DARPA programs have been identified as most relevant to the PEO LS portfolio and demonstrate the potential to support the future direction of the PEO.

Squad-X

DARPA's Squad X Core Technologies (SXCT) program aims to develop novel technologies that could be integrated into user-friendly systems that would extend squad awareness



and engagement capabilities without imposing physical and cognitive burdens. The goal is to speed the development of new, lightweight, integrated systems that provide infantry squads unprecedented awareness, adaptability and flexibility in complex environments, and enable dismounted Soldiers and Marines to more intuitively understand and control their complex mission environments.

High-Assurance Cyber Military Systems (HACMS)

The goal of the HACMS program is to create technology for the construction of high-assurance cyber-physical systems, where high assurance is defined to mean functionally correct and satisfying appropriate safety and security properties. Achieving this goal requires a fundamentally different approach from what the software community has taken to date. Consequently, HACMS will adopt a clean-slate, formal methods-based approach to enable semi-automated code synthesis from executable, formal specifications. In addition to generating code, HACMS seeks a synthesizer capable of producing a machine-checkable proof that the generated code satisfies functional specifications as well as security and safety policies. A key technical challenge is the development of techniques to ensure that such proofs are composable, allowing the construction of high-assurance systems out of high-assurance components. Key HACMS technologies include interactive software synthesis systems, verification tools such as theorem provers and model checkers, and specification languages.

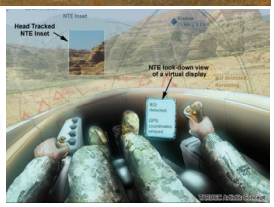
Advanced RF Mapping (Radio Map)

DARPA's Advanced RF Mapping (RadioMap) program seeks to provide real-time awareness of radio spectrum use across frequency, geography and time. The goal is to provide a map that gives an accurate picture of spectrum use in complex environments. With this information, spectrum managers and automatic spectrum allocation systems can operate much more efficiently, reducing the problems caused by spectrum congestion and enabling better mitigation of interference problems. The program plans to provide this information in part by using radios deployed for other purposes, like data and voice communications systems. The program aims to develop ways to use the capabilities of modern radios to sense the spectrum when they are not communicating.

Ground Experimental Vehicle Technologies (GXV-T)

Develop next generation ground platform technologies that improve expeditionary mobility, combined factors of tactical and strategic, without sacrificing survivability.

The trend of increasingly heavy, less mobile and more expensive combat platforms has limited Soldiers' and Marines' ability to rapidly deploy and maneuver in theater and accomplish their missions in varied and evolving threat environments. Moreover, larger vehicles are limited to roads, require more logistical support and are more expensive to design, develop, field and replace. The U.S. military is now at a point where—considering tactical mobility, strategic mobility, survivability and cost—innovative and disruptive solutions are necessary to ensure the operational viability of the next generation of armored fighting vehicles.



DARPA's Ground X-Vehicle Technologies (GXV-T) program seeks to help overcome these challenges and disrupt the current trends in mechanized warfare. GXV-T seeks to investigate revolutionary ground-vehicle technologies that would simultaneously improve the mobility and survivability of vehicles through means other than adding more armor, including avoiding detection, engagement and hits by adversaries. This improved mobility and warfighting capability would enable future U.S. ground forces to more efficiently and cost-effectively tackle varied and unpredictable combat situations.

The GXV-T program seeks to develop advanced technologies in the following four technical areas:

- Enhanced Platform Mobility – Ability to traverse diverse off-road terrain, including slopes and various elevations.
- Enhanced Platform Agility – Autonomously avoid incoming threats without harming occupants through technologies that enable, for example, agile motion and active repositioning of armor.
- Crew Augmentation – Improved physical and electronically assisted situational awareness for crew and passengers; semi-autonomous driver assistance and automation of key crew functions similar to capabilities found in modern commercial airplane cockpits.
- Signature Reduction – Reduction of detectable signatures, including visible, infrared (IR), acoustic and electromagnetic (EM).

Aerial Reconfigurable Embedded System (ARES)

ARES is a vertical takeoff and landing (VTOL) flight module designed to operate as an unmanned platform capable of transporting a variety of payloads. The ARES VTOL flight module is designed to have its own power system, fuel, digital flight controls and remote command-and-control interfaces. Twin tilting ducted fans would provide efficient hovering and landing capabilities in a compact configuration, with rapid conversion to high-speed cruise flight. It is envisioned that the flight module would travel between its home base and field operations to deliver and retrieve several different types of detachable mission modules, each designed for a specific purpose.

Fast Lightweight Autonomy (FLA)

The goal of the FLA program is to explore non-traditional perception and autonomy methods that could enable a new class of algorithms for minimalistic high-speed navigation in cluttered environments. The program focuses on autonomy and not on the flight platform, where "autonomy" includes sensing, perception, planning, and control. Autonomous flight capabilities are being developed and demonstrated using custom payloads on small commercial airframes.

Offensive Swarm-Enabled Tactics (OFFSET)

DARPA's OFFensive Swarm-Enabled Tactics (OFFSET) program envisions future small-unit infantry forces using swarms comprising upwards of 100 small-unmanned aircraft systems (UASs) and/or small-unmanned ground systems (UGSs) to accomplish diverse missions in complex urban environments. By leveraging and combining emerging technologies in swarm autonomy and human-swarm teaming, the program seeks to enable rapid development and deployment of breakthrough capabilities.

Improv 1 and 2

The goal of the Improv program is to assess and counter the threats emerging as a result of these diminished barriers to entry by (1) developing representative examples of military capabilities made possible by the existence of easily obtainable knowledge and technology and (2) developing countermeasures as well as U.S. capabilities based upon those examples.

Aerial Dragnet

DARPA's Aerial Dragnet program aims to achieve the technically difficult goal of detecting and tracking small UASs in urban terrain. The program seeks innovative technologies to provide persistent, wide-area surveillance of all UAS operating at low altitudes in a large city. While Aerial Dragnet's focus is on protecting military troops operating in urban settings overseas, the system could ultimately find civilian application.

Prototype Resilient Operations Testbed for Expeditionary Urban Scenarios (PROTEUS)

The goal of the Prototype Resilient Operations Testbed for Expeditionary Urban Operations (PROTEUS) program is to create and demonstrate tools to develop and test agile expeditionary urban operations concepts based on dynamically composable force packages.